Summary of GMI Activities, October 2004-April 2005

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Tropospheric Model and Simulations

GMIT-V1 (DAO, CCM3, GISS)

Version 1 runs with DAO, CCM3, and GISS were completed before the last Science Team Meeting (Nov. 2004). At the meeting, the results were examined and the team decided they were not happy with CCM3 met fields lacking shallow convection. The team also decided that the GISS convection might had never have been implemented correctly since shallow and deep convective fluxes had been lumped together. Also, downdrafts had not been implemented for GISS. In the month following the meeting there was considerable discussion on how to proceed. There was a consensus on what to do with each set of met fields:

1. CCM3: Replace these met fields with the new FVGCM fields, which have the same physics package and have the needed convective fields.

2. GISS: M. Prather separated shallow and deep convection for the GISS met fields, which were originally lumped together. This analysis was based on Prather's examination of GISS fields that had separate shallow and deep convection components. Now, shallow and deep convection are implemented as separate processes. In addition, Dan Bergmann implemented transport by downdrafts for the GISS fields.

3. DAO: There were no changes in the treatment of convection for DAO because the DAO meteorological fields never had downdrafts.

These changes are considered part of 'Version 2'.

GMIT-V2 (DAO, FVGCM, GISS)

The tropospheric model is now updated to 'Version 2'. A summary of the changes between V1 and V2 can be found on the GMI web site:

http://gmi.gsfc.nasa.gov/models/gmit-v2_summary.pdf

This version includes the effects of aerosols on heterogeneous chemistry and photolysis rates; previously only chemistry on sulfates was included. 'V2' uses Fast JX, which is essentially the same as Fast J for the troposphere (and includes hydrocarbon photolytic rate information), but adds optimized wavelength bins for the stratosphere. The aerosol climatology was updated because of an error discovered in the old climatology (1997). Updates were obtained from the Go-Cart Model (Mian Chin) and represent 2002 aerosols.

Before new simulations could be run with the FVGCM met fields, a convective routine was required for the calculation transport by deep (tropical) convection (Zhang-McFarlane) and shallow (midlatitude) convection (Hack). After consultation with P. Rasch, we implemented a new convection subroutine from NCAR, modified and implemented by Steve, that could make use of entrainment and detrainment fields from the FVGCM. This subroutine is called separately for each type of convection. There are downdrafts in the deep convection and wet scavenging occurs in updrafts (in both shallow and deep convection).

New runs are available for GMIT-V2 for DAO and GISS. An FVGCM run (4x5 resolution with 42 levels) has been completed but is still under evaluation. Simple tracer (CO2, anthro-CO, b.b-CO, CH3I-like tracer) and radionuclide simulations using all 3 sets of met fields have just been completed with Version 2. David has also summarized the GMI radionucleide calculations in a draft manuscript for publication.

The Science Team pointed out some inconsistencies in the ozone balance utilizing the available diagnostics (tendencies, production and loss, and vertical fluxes). The cause of this discrepancy has now been resolved by Bryan; it was essentially due to errors in the adopted molecular weights of the species which arose from optimizations in the chemical mechanism and transport. This correction is incorporated into Version 2.

Other Tropospheric Model Activities

Bhat has implemented the Pickering and Allen lightning parameterization. Changes to the GISS convection required a review of the parameterization. The parameterization has been adapted to use cloud mass fluxes from the new FVGCM met fields. For all met fields, emissions-only runs are planned to determine the global scaling factor necessary to produce the desired budget of lightning NO (Tg N/yr).

Three GMI models participated in the IPCC photochemistry intercomparison exercise. Some minor model recoding was required to produce column outputs for some species (NO_2, CH_2O, O_3). Simulations were submitted for GMI-DAO, GMI-CCM, and GMI-GISS. Jose attended the workshop in January. In preparing the model for these simulations, Bryan updated SYNOZ flux to 550 Tg/year (up from 475). Lightning NO_x was renormalized from 5 to 7 Tg N/year (for IPCC). Diagnostics were added to quantify on-line emissions of soil NO_x and CO as derived from the oxidation of several biogenic hydrocarbons (i.e., propene, monoterpenes, and methanol).

Steve updated the treatment of water vapor saturation with respect to ice. The old parameterization was a computationally intensive polynomial fit that worked down to 223K. The updated calculation uses the formulation of Marti & Mauersberger [GRL, 1993] and is valid for 170-273K. In practice, this change had little effect water vapor.

Aerosol and Microphysical Model and Simulations

The convection issues that arose at the November 2004 meeting affected both the tropospheric and aerosol models. Once the convection issues were resolved, new simulations with DAO and GISS met fields were rerun. The new convection implementation, described above, was a prerequisite for running an aerosol simulation with FVGCM met fields. A simulation with FVGCM met fields is now complete (4x5 resolution) and is being examined.

Bhat has recently completed implementation of the Michigan microphysical model. We are beginning to test it with DAO met fields.

Stratospheric Model and Simulations

The two 50-year hindcast simulations, one with a repeating cold Arctic winter and the other with a repeating warm Arctic winter, were completed. The period simulated was 1975-2025.

Combined Strat-Trop Chemistry Model and Simulations

Before the November meeting, David Considine and the core team finished two 1-year run 'combo' runs with CCM3 met fields: one with Fast JX throughout and the other with Fast J (troposphere) and the look up table (stratosphere). By comparing these runs, David identified some problems with O^1D in the troposphere. These were subsequently corrected by adjusting error tolerances in SMVGEAR.

We have integrated several test years with the FVGCM met fields at 4x5x42 levels. Fast JX is now being used for all photolysis. Initial examination shows that the troposphere and stratosphere are behaving much the way they do in the 'single mechanism' models. Bryan and Jules reduced the number of species advected from about 124 to about 70 with a total run speed-up of about 7%. Jules expects a faster speed-up of about 10% on 64 processors and 13-15% on 128 processors. The combo model results are still under evaluation.

Using the KMG kinetics software written by Peter Connell, David has successfully implemented the Langley chemical mechanism as alternative for the GMI strat-trop mechanism. This mechanism is currently solved using SMVGEAR, but David is working on a shell code that will interface the Langley chemical solver with the GMI model. The Langley solver is expected to be more efficient for the Langley mechanism.

New Met Fields

We are now using new FVGCM met fields, also known as the GEOS-4 AGCM (but with slight differences between this build and the standard GEOS-4). Steve has processed 1-year of these fields onto a 4x5x42 level grid for use in the tropospheric, aerosol, and combined models. The original vertical grid contained 55 levels. The 42 levels chosen

include the original 31 levels from the surface to 10 mb and reduced resolution above. The model lid is 0.015 mb.

Cloud optical depth (OD) in the met fields is extremely low, especially in the upper troposphere. This is a known GEOS-4 pathology, and is worse than the DAO-STRAT OD in the upper troposphere. Because the FVGCM appears to have reasonable cloud fractions and humidity, we think it may be possible to circumvent the low (OD) by using a parameterization to estimate OD with other meteorological quantities to estimate optical depth. Testing of this parameterization is ongoing.

We also have met fields for Jan-April 2000 for GEOS-4, both assimilated fields and forecast fields. They are not yet processed for use.

Numerical Experiments

We now have 'ncregrid', a general purpose, non-interpolating method for regridding fields. We think this is the right tool to begin the 'doubling to convergence' experiments with M. Prather.

Miscellaneous

Proposed work with UEET (Ultra Efficient Engine Technology Program) has been cut.

Tom and Jules are working on making the GMI chemical mechanisms ESMF compliant.

Aircraft emission inputs were regridded after a discovery that there were errors in the way that the original emissions were regridded onto our vertical coordinates.

Bhat worked with Bryan to modify code from Randall Martin that processes GOME data and model output for model evaluation. Jules and Bryan worked together to modify code from Prasad Kasibhatla that processes MOPITT data and model output for model evaluation.

Jules and Bhat have created a netCDF utility library (code, documentation, and sample codes) written in Fortran 90. The library can be used to manipulate netCDF files and it simplifies netCDF calls. Jules has used this library to reduce the model code by more than 700 lines. After further in house testing, the library will be available on the GMI web site. The library is being used for the processing of GOME and MOPITT data.

Thanos Nenes and Nicholas Meskhidze have successfully ported the GMI code to their local machine at Georgia Tech. They are in the process of incorporating their cloud activation algorithm into the GMI model.

Tom Kuscera is our newest core team member. Tom supports GMI part-time and so far has worked on processing model inputs and outputs.